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Appendix B – Supporting Documentation

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

March 2021

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Introduction

This appendix presents detail on three sensitivity assessments completed to support the East Waterway (EW) anthropogenic background (AB) evaluation. The results of these assessments are discussed in the main body of this document. This appendix includes the following three parts:

- Part 1 – River Flow and Precipitation Weighting
- Part 2 – Particle Grain Size Surface Area Adjustment
- Part 3 – Urban Inputs

Part 1 – River Flow and Precipitation Weighting

Green River suspended solids characteristics are largely influenced by two factors: the volume of water being released by the Howard Hanson Dam and the amount of recent precipitation. Both the U.S. Geological Survey (USGS) suspended solids study (Conn et al. 2018) and the King County suspended solids study (King County 2016) categorized flow conditions within the Green River based on the volume of dam release and precipitation conditions during and just before sampling. The two studies differed slightly in the details of their approach (i.e., which precipitation gauge was used) but used the same general methodology. Low dam flow with low (or no) precipitation was categorized as "baseflow"; high dam flow with low or no precipitation was categorized as "dam"; low dam flow with high precipitation was categorized as "storm"; and high dam flow with high precipitation was categorized as "storm+dam." Figures 2-6 and 2-7 of the main text provide flow and precipitation histograms for years 2001 to 2019. Figures B-1, B-2, and B-3 present contaminant concentrations under different flow and precipitation conditions, with flow below the dam (average from USGS station 12105900 during sampling) on the x-axis, and precipitation during and 12 hours before sampling (Tukwila rain gauge) on the y-axis, with the size of the markers scaled to show chemical concentration. The color indicates the season during which the sample was collected. All three contaminants have lower concentrations (smaller circles) at higher flows, due to significant dam release[1] (to the right on the graph). Toward the origin (to the left on the graph), the data show higher concentrations and more variation, with higher concentrations for organics during higher precipitation events (up on the graph; Figures B-1 and B-2), and higher concentrations for arsenic during lower precipitation events representative of baseflow (down on the graph; Figure B-3).

This information was used for the conceptual site model outlier evaluation (Section 4.5.1 of the main text) and for the river flow and precipitation weighting sensitivity analysis (Section 4.6 of the main text). Additional details on the river flow and precipitation weighting sensitivity analysis are provided in the following paragraphs.

To apply river flow and precipitation weighting, the data depicted in Figures B-1 through B-3 were binned into four quadrants along the x- and y-axes in the figures. The binning thresholds were selected based on trends in the distribution of the data across the flow and precipitation conditions (i.e., to more evenly distribute sample counts within each bin). The dam flow threshold was set at 2,000 cubic feet per second (average during sampling), reflecting higher flows associated with a significant dam release, and the precipitation threshold was set at 0.25 inches per day for the analysis, reflecting precipitation events that contribute to stormwater runoff. Both thresholds are generally consistent with the USGS and King County evaluations (Conn et al. 2018; King County 2016). The data were then binned into the four quadrants created from these two thresholds based

[1] As adopted by USGS and King County studies, a significant dam release is considered 2,000 cubic feet per second or greater at the base on the Howard Hanson Dam.

on the conditions during sampling: low flow, low precipitation; low flow, high precipitation; high flow, low precipitation; and high flow, high precipitation.

A weighted average concentration was calculated based on the time that the Green River is in each of the four river flow/precipitation conditions. The number of days that the river is in each condition was calculated based on the data from 2001 to 2019 (calendar years for which data was available for the selected flow and precipitation gauges). The number of days in each of the four river flow/precipitation conditions was divided by the total duration from 2001 through 2019 to estimate the percentage that the river is in each river flow/precipitation condition. Then, the average concentration for each quadrant was multiplied by the percentage for each to calculate a weighted average concentration. The results of this weighting calculation are presented in Section 6 of the main text.

Part 2 – Particle Grain Size Surface Area Adjustment

This section provides additional details related to Section 4.6.3 of the main text. This adjustment assumes that organic contaminant mass is distributed to the organic carbon that is proportional to the surface area of particles (e.g., Hedges and Kiel 1995; Karickhoff et al. 1979; Wang and Keller 2008), then calculates the concentration of suspended solids entering the EW considering the changes in the particle size distribution between the Green River and the EW. The components of the calculation are shown in Table B-1 and described by the following steps:

1. Extract the average particle size distribution by mass from the Lower Duwamish Waterway (LDW) sediment transport model data for suspended solids entering the LDW (i.e., in the Green River).
2. Calculate the surface area-to-mass ratio for each particle size category for particles based on the effective particle diameter for each category, assuming a spherical shape and a typical particle density for each category.
3. Multiply the surface area-to-mass ratio (from Step No. 2) times the mass for the particle size category (from Step No. 1) to calculate the total surface area for each particle size category.
4. Calculate the average contaminant concentration without particle size adjustments for organic contaminants from the AB dataset.
5. Calculate the contaminant mass associated with each particle size category for a unit contaminant mass by multiplying the average concentration (from Step No. 4) times the surface area for each particle size category and dividing by the total surface area for all the categories (from Step No. 3).
6. Divide the contaminant mass associated with each particle size category by the total mass associated with each particle size category (from Step No. 1) to get the concentration for each particle size category.
7. Extract the average particle size distribution by mass from the LDW sediment transport model data for suspended solids exiting the LDW (i.e., entering the EW).
8. Multiply the contaminant concentrations for each particle size category (from Step No. 6) by the percent of mass entering the EW for each particle size category (from Step No. 7) to calculate the weighted average concentration of all particulate entering the EW.

The results shown in Table B-1 are discussed in Section 5 of the main text.

Part 3 – Urban Inputs

This section provides additional details related to the urban inputs discussed in Section 5.5 of the main text. The available datasets for the EW lateral solids samples are presented in the EW Supplemental Remedial Investigation Appendix I and EW Feasibility Study Appendix B, Part 4, and the laterals datasets for the LDW have recently been aggregated in the *Lower Duwamish Waterway Pre-Design Studies Data Evaluation Report* (Windward 2020). Lateral input data were aggregated using a sample-by-sample evaluation that considers the sample location in the context of the pipe network and the age of the data to identify samples that are most representative of current conditions. The general rules for aggregating lateral input data are as follows:

- Prioritize data to be the most representative of what is entering the waterway by including only the in-line samples closest to the end of the pipe.
  - If end-of-pipe in-line samples are not available, include other in-line samples collected further up the pipe, plus catch basin samples collected downstream of the in-line samples.
  - If no other in-line samples are available, use catch basin samples collected throughout the system.
- If an area has had line cleaning or significant remedial or source control actions, only use data following the action(s). If no significant source control actions have been conducted, include all available data for that location.

The most recent application of this approach for LDW laterals resulted in 379 samples for PCBs, 351 samples for arsenic, and 57 samples for dioxins/furans (Windward 2020). The EW FS laterals data aggregation resulted in 261 samples for PCBs, 255 samples for arsenic, and 20 samples for dioxins/furans. These laterals datasets have an adequate number of samples that meet sample acceptability standards and are representative of current conditions.

As described in Section 3.2 of the main text, urban inputs from downstream of the Green River river mile (RM) 10.4 were not included in AB estimates because of challenges in estimating concentrations when source control actions are not complete and because of the relatively small contribution of solids mass entering the EW compared to Green River. Urban inputs that are not captured by the AB dataset include lateral inputs to the EW, lateral inputs to the LDW, and lateral inputs to the Duwamish River between the LDW (RM 5.0) and the sampling location (RM 10.4). However, urban inputs (that not associated with Comprehensive Environmental Response, Compensation, and Liability Act releases) are part of background that will affect the EW in the future. Therefore, the effect of future urban input on AB was estimated in a sensitivity evaluation.

The sensitivity evaluation was performed by calculating a weighted average concentration of Green River suspended solids (i.e., the AB dataset) with EW and LDW lateral inputs (i.e., lateral datasets). The calculation does not account for LDW bedded sediment that can resuspend and travel downstream into the EW or lateral inputs to the Green River upstream of the LDW, which would increase the mass of the laterals input. The mass inputs are based on EW FS modeling estimates for anticipated future conditions, which assigns 11,000 metric tons a year from the Green River and 110 metric tons a year from EW and LDW lateral inputs (based on EW FS Table J-1 calculated for 1.2 cm/year average deposition for the future case; see Figure 2-2 of the main text). The concentration in Green River suspended solids for this analysis was estimated based on the dataset without fines adjustment, consistent with the other sensitivity analysis (Section 5.1 of the main text). The lateral inputs concentrations following future source control actions were estimated based on best professional judgment of the source control implementation leads. The lateral loads were estimated based on the recently compiled LDW lateral dataset presented in Table 8-1 of the *Lower Duwamish Waterway Pre-Design Studies Data Evaluation Report* (Windward 2020). In addition to the screening steps outlined in bullets above, additional adjustments to the LDW laterals dataset were made to exclude values that are expected to be controlled by source control actions[2]:

- PCBs: excluding all samples above 2,000 micrograms per kilogram (µg/kg)
- Dioxin/furan toxic equivalent (TEQ): excluding three extreme values
- Arsenic: excluding all samples above 57 milligrams per kilogram (mg/kg)

The median values from Table 8-1 were used to represent both the EW and LDW lateral inputs as follows: PCBs: 97 µg/kg dw; dioxin/furan TEQ: 26 nanograms per kilogram dw; arsenic: 10 mg/kg dw. The median was selected as representative of post-source control concentrations.

The results of the analysis are discussed in Section 5 of the main text.

[2] There was one outlier concentration from dioxin/furan dataset that was also removed.

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Table

Figures